ARMSTRONG PROCEDURAL REQUIREMENTS (DPR)		**Directive:**	**DPR-7123.1-001D**
		Effective Date:	**April 1, 2016**
		Expiration Date:	**April 1, 2021**

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SUBJECT: Systems Engineering Requirements Document

RESPONSIBLE OFFICE: R/Director of Research Engineering

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PREFACE

P.1 Purpose

a. The purpose of this document is to establish the Center's requirements for the implementation of systems engineering practices in accordance with NPR 7123.1. Systems engineering is a logical systems approach performed by multidisciplinary teams to engineer and integrate the Center's systems to ensure products meet customers' needs. This systems approach is applied to all elements of a system and all hierarchical levels of a system over the complete project life cycle.

P.2 Applicability

a. This document and the requirements identified within it apply to all flight projects and major ground support system development projects managed by the Center. It applies to products that are intended to be flown as well as (to the greatest extent practical) products used in direct support of flight, including experiments, simulation, and software used for verification or validation of flight products. To the extent practical, it also applies to Center products affecting flight, such as office software tools. This includes products designed for flight research, such as analysis tools, control rooms tools, corrective action systems, and configuration management systems, etc.

b Through partnerships with industry, academia, other NASA Centers, and other government agencies, the Center enters into projects at various stages of their lifecycles, often just prior to the operations phase. The applicability of this DPR and other Center requirements will be identified during the negotiation of the partnership agreements. In cases where these requirements are not invoked, a suitable alternate systems engineering approach will be identified.

c. Many other discipline areas such as safety, medical, reliability, maintainability, quality assurance, information technology, security, logistics, and environmental, etc., perform functions during project life-cycle phases that influence or are influenced by the engineering organizations, and the requirements of those functions need to be fully integrated with the engineering functions. The interactions of the engineering processes with these enabling processes are described in the Armstrong Management Systems Manual (AMSM).

P.3 Authority

a. NPR 7120.5, NASA Space Flight Program and Project Management Requirements

b. NPR 7123.1, NASA Systems Engineering Processes and Requirements

c. NPR 1280.1, NASA Integrated Management System Policy

d. NPR 7150.2, NASA Software Engineering Requirements

P.4 Applicable Documents

a. G-7120.5-001, Project Chief Engineer's Handbook

b. SAE AS9100, Aerospace Quality Management System Standard

P.5 Measurement/Verification

a. The methods to ensure compliance with this DPR and NPR 7123.1 will be documented in the Systems Engineering (SE) implementation procedures and through internal and external assessments and audits.

P.6 Cancellation

DPR-7123.1-001B, Systems Engineering Requirements Document, dated March 9, 2011.

David McBride, Center Director

3/29/2016

Date

CHAPTER 1: INTRODUCTION

1.1 Project Lifecycle

1.1.1 The Center system engineering requirements are defined to establish a standard, disciplined engineering approach to systems development throughout the lifecycle of a project. In alignment with NPR 7120.5 and NPR 7123.1, the project lifecycle shown in Figure 1 has been defined for projects performed by the Center.

1.1.2 The lifecycle is intended to be a standard for the Center's projects, but it is common for the Center to enter into partnerships with external entities on existing projects at various stages of their lifecycles. The requirements of this DPR are intended to ensure consistency between all projects being conducted at the Center.

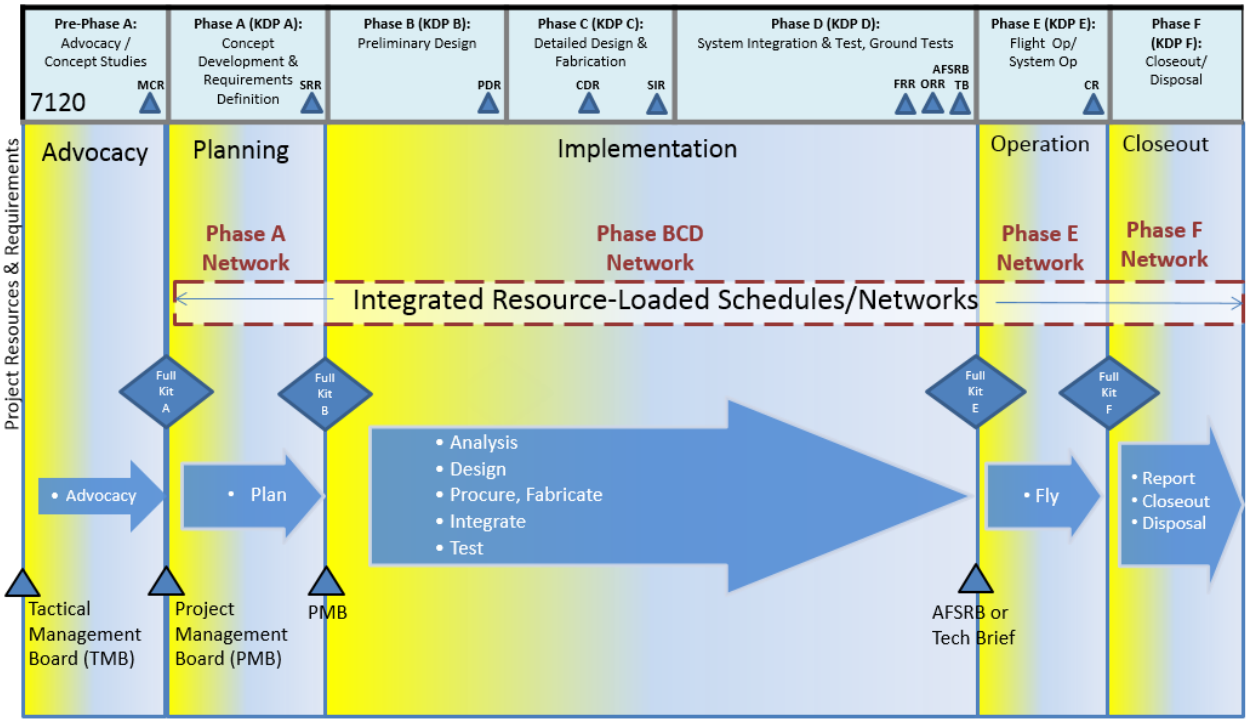

Figure 1. Armstrong Project Lifecycle

KDP – Key Decision Point
SMB – Strategic Management Board
PMB – Program Management Board
MCR – Mission Concept Review
SRR – Systems Requirement Review
PDR – Preliminary Design Review
CDR – Critical Design Review
SIR* – Systems Integration Review
FRR – Flight Readiness Review
AFSRB – Airworthiness and Flight Safety Review Board
TB – Tech Brief
ORR – Operational Readiness Review
DR – Data Review and/or Decommissioning Review
TRR* – Test Readiness Review

* Not required unless specified in the Project Plan

1.2 DPR Scope

1.2.1 This document describes the Center's implementation of the requirements in NPR 7123.1.

1.3 Roles and Responsibilities

1.3.1 Per NPR 7123.1, Section 2.3, the Designated Governing Authority (DGA) for the technical effort described in this DPR begins with the Center Director. From there, authority is delegated to the Director of Flight Operations or Director of Research Engineering. Authority for issues that relate to the application of aircraft airworthiness standards for modification, operation, or maintenance of aircraft are further delegated through the Director of Flight Operations to a project's Lead Operations Engineer. Authority for issues related to the application of technical requirements and standards, including the approval of waivers, are delegated to the Project's Chief Engineer through the Director for Research Engineering. See Figure 2 for a graphical representation of this process.

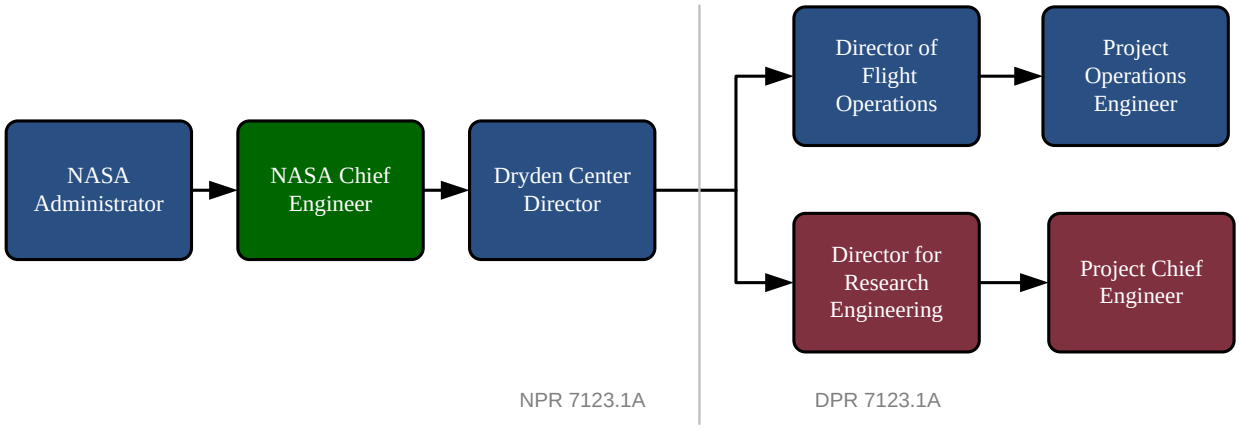

Figure 2. Flow of Technical Designated Governing Authority at Armstrong

1.4 Complying with Agency Requirements

1.4.1 Center projects shall (2) meet the intent of the requirements allocated to projects by NPR 7123.1. Guidance for meeting the intent of the project-allocated requirements is contained in G-7120.5-001, Project Chief Engineer's Handbook. The method of compliance for each requirement is documented in the project Systems Engineering Management Plan (SEMP) or equivalent.

1.5 NPR 7123.1b requirements allocated to the Center

1.5.1 The compliance matrix mandated by NPR 7123.1b requirement SE-04 is found in Appendix X. The matrix references other Center documents in which the relevant policies, procedures and processes may be found for each NPR 7123.1b requirement

allocated to the center. Those implementations requiring further description are described here.

1.6 Process Improvement

1.6.1 The Chief of the Systems Engineering branch will identify at least two improvement areas each year and brief the Director for Research and Engineering at least quarterly on the efforts made at improvement.

1.6.2 The Chief of the Systems Engineering branch will identify design review metrics and collect those metrics in a library on the branch's Sharepoint site. Metrics will be reviewed at least quarterly and will be used to identify areas to consider for process improvement.

1.7 Standards

1.7.1 The documents listed in the Section P.4 represent the standards that all Center projects shall implement. Project Chief Engineers are responsible for working with the Project Manager and the Lead Operations Engineer to implement design standards appropriate for each project.

1.8 NPR 7123.1b requirements allocated to Projects

1.8.1 The Project Chief Engineer is responsible for completing the SEMP worksheet (G-7120.5-001, Appendix C) or equivalent and obtaining the required signatures before SRR or, in the case of a project that has arrived at the Center in a later phase, at a milestone negotiated by the Director for Research and Engineering and the Project Chief Engineer. The SEMP worksheet or equivalent, when completed, stands as the compliance and implementation agreement and the engineering review plan agreement between the project and the Director for Research and Engineering.

1.8.2 The Chief of the Systems Engineering and Integration branch will collect SEMP worksheets and equivalents in a library available on the branch's Sharepoint site.

CHAPTER 2: AS9100 (AEROSPACE QUALITY MANAGEMENT SYSTEM STANDARD) REQUIREMENTS

2.1. First Article (AS9100)

2.1.1 SAE AS9100, Aerospace Quality Management System Standard, has two unique additional requirements that will be addressed in the implementation of DPR-7123.1-001. The first requirement has to do with independent verification and validation of the first unit produced prior to handover to manufacturing.

2.1.2 The Center's definition of "first article" is "First unit produced for full compliance to requirements meeting final intended purposes of the customer. At the Center, this is defined as the output from a research design and development environment."

2.1.3 The Center does not process products in volume production runs, and therefore does not perform independent first article inspections. The intent of first article inspection will be accomplished through the verification and validation activities of the design and development lifecycle.

2.2 Key Characteristics (AS9100)

2.2.1 The second unique SAE AS9100 requirement has to do with the identification of key characteristics during the design and development process and the flowdown of key characteristics to the in-house manufacturing organizations and/or suppliers through the purchasing processes.

2.2.2 The Center's definition of key characteristics is "Key characteristics are defined as the features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, manufacturability, or with a clear and imminent safety impact if it is not complied with (e.g., output voltage, shields/covers, warning markings, etc.)."

2.2.3 Key characteristics will be identified and evolved throughout the project lifecycle.

2.2.4 Functional key characteristics are the features of a system, subsystem, or assembly whose attributes are more suitably verified through analysis and/or test.

2.3.5 A customer is more likely to define the objectives and goals of what they desire in terms of function, features, performance, and data. The prioritization of customer requirements and objectives by the project manager defines the customer's key characteristics. The project manager shall document these requirements in an appropriate project agreement document (e.g., Objectives and Requirements Document, System Requirements Document, etc.).

2.2.6 The design organization shall specify and document physical key characteristics for material, hardware, and systems. Appropriate testing will be formulated and documented to verify that the key characteristics have been achieved.

2.2.7 For parts that are designed and fabricated by an off-site vendor, the vendor shall be provided by the purchasing organization with sufficient documentation, including identification of key characteristics, to ensure that the vendor provides the desired product.

2.2.8 Design and development organizations shall transmit key characteristics to the internal fabrication function(s) via drawings, associated inspection plans, or other applicable documents.

2.2.9 A Quality Engineering function shall perform a risk-based review of the drawings and specification documents and, in conjunction with the design organization, may identify additional key characteristics that would be added to drawings or other applicable documents as appropriate.

2.2.10 The Quality Assurance organizations shall verify adherence to key characteristics for all on-site and off-site fabricated parts prior to release for delivery.

Appendix A: Definitions

A.1 First Article. First unit produced for full compliance to requirements meeting final intended purposes of the customer. At the Center, this is defined as the output from a research design and development environment.

A.2 Formulation Phase. See NPR 7120.5 for definitions of program phases.

A.3 Key Characteristics. Key characteristics are defined as the features of a material, process, or part whose variation has a significant influence on product form, fit, function, performance, service life, manufacturability, or with a clear and imminent safety impact if it is not complied with (e.g., output voltage, shields/covers, warning markings, etc.).

A.4 Verification. Proof by examination of objective evidence that the product complies with specifications. Verification is performed to ensure the product complies with requirements and may be determined by test, analysis, demonstration, inspection, or a combination of these.

A.5 Validation. Proof by examination of objective evidence that the product accomplishes the intended purpose. Validation is performed to ensure that the product is ready for a particular use, function, or mission, and may be determined by test, analysis, demonstration, or a combination of these.

Appendix B: Acronyms

AFSRB	Airworthiness and Flight Safety Review Board
CDR	Critical Design Review
ConOps	Concept of Operations Document
DGA	Designated Governing Authority
DR	Data Review and/or Decommissioning Review
FRR	Flight Readiness Review
KDP	Key Decision Point
MCR	Mission Concept Review
ORD	Objectives and Requirements Document
ORR	Operational Readiness Review
ORRP	Operational Readiness Review Panel
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PM	Program Manager
PMB	Program Management Board
QE	Quality Engineer
SAE	Society of Automotive Engineers
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SIR	Systems Integration Review
SMB	Strategic Management Board
SRD	System Requirements Document
SRR	Systems Requirement Review
TB	Tech Brief
TRR	Test Readiness Review
WBS	Work Breakdown Structure

Appendix C: Mapping of NPR 7123.1 Common Technical Processes

C.1 The goal of this Appendix is to establish traceability of NPR 7123.1 Common Technical Process requirements with elements in this DPR and additional guidance information.

NPR Reqt		Comply?	Justification
SE-01	Center Directors shall perform the following activities: establish policies, procedures, and processes to execute the requirements of this SE NPR	Yes	This document describes the policies, procedures and processes to execute the requirements for the SE NPR.
SE-02	Center Directors shall perform the following activities: assess and take corrective actions to improve the execution of the requirements of this SE NPR.	Yes	See Section 1.4.1 of this document
SE-03	Center Directors shall perform the following activities: select appropriate standards applicable to projects under their control.		See Section 1.4.1 of this document.
SE-04	Center Directors shall perform the following activities: Complete the compliance matrix, as tailored, in Appendix H.1 for those requirements owned by the Office of Chief Engineer, and provide to the OCE upon request.	Yes	This matrix
SE-07	Center Directors or designees shall establish and maintain a Stakeholder Expectations Definition process to include activities, requirements, guidelines, and documentation for the definition of stakeholder expectations for the applicable product layer.	Yes	Guidelines for stakeholder expectation definition in G-7120.5-001 section 4.1.1 and Appendix C
SE-08	Center Directors or designees shall establish and maintain a Technical Requirements Definition process to include activities, requirements, guidelines, and documentation for the definition of technical requirements from the set of agreed upon stakeholder expectations for the applicable product layer.	Yes	Guidelines for Technical Requirements Definition in G-7120.5-001 section 4.2.1 and Appendix C
SE-09	Center Directors or designees shall establish and maintain a Logical Decomposition process to include activities, requirements, guidelines, and documentation for logical decomposition of the validated technical requirements of the applicable product layer.	Yes	Guidelines for Logical Decomposition in G-7120.5-001 section 4.2.1 and Appendix C
SE-10	Center Directors or designees shall establish and maintain a Design Solution Definition process to include activities, requirements, guidelines, and documentation for designing product solution definitions within the applicable product layer that satisfy the derived technical requirements.	Yes	Guidelines for Design Solution Definition in G-7120.5-001 sections 4.3, 4.4 and Appendix C

NPR Reqt		Comply?	Justification
SE-11	Center Directors or designees shall establish and maintain a Product Implementation process to include activities, requirements, guidelines, and documentation for implementation of a design solution definition by making, buying, or reusing an end product of the applicable product layer.	Yes	Guidelines for Product Implementation in G-7120.5-001 section 4.5 and Appendix C
SE-12	Center Directors or designees shall establish and maintain a Product Integration process to include activities, requirements, guidelines, and documentation for the integration of lower level products into an end product of the applicable product layer in accordance with its design solution definition.	Yes	Guidelines for Product Implementation in G-7120.5-001 section 4.5 and Appendix C
SE-13	Center Directors or designees shall establish and maintain a Product Verification process to include activities, requirements/specifications, guidelines, and documentation for verification of end products generated by the product implementation process or product integration process against their design solution definitions.	Yes	Guidelines for Product Implementation in G-7120.5-001 section 4.5 and Appendix C
SE-14	Center Directors or designees shall establish and maintain a Product Validation process to include activities, requirements, guidelines, and documentation for validation of end products generated by the product implementation process or product integration process against their stakeholder expectations.	Yes	Guidelines for Product Implementation in G-7120.5-001 section 4.5 and Appendix C
SE-15	Center Directors or designees shall establish and maintain a Product Transition process to include activities, requirements, guidelines, and documentation for transitioning end products to the next higher level product layer customer or user.	Yes	Guidelines for Product Implementation in G-7120.5-001 section 4.5 and Appendix C
SE-16	Center Directors or designees shall establish and maintain a Technical Planning process to include activities, requirements, guidelines, and documentation for planning the technical effort.	Yes	Guidelines for technical planning inn G-7120.5-001 section4.1.3 and Appendix C
SE-17	Center Directors or designees shall establish and maintain a Requirements Management process to include activities, requirements, guidelines, and documentation for management of requirements throughout the system life cycle.	Yes	Guidelines for Requirements Management in G-7120.5-001 Appendix C
SE-18	Center Directors or designees shall establish and maintain an Interface Management process to include activities, requirements, guidelines, and documentation for management of the interfaces defined and generated during the application of the system design processes.	Yes	Guidelines for Interface Management in G-7120.5-001 Sections 4.3 and 4.4
SE-19	Center Directors or designees shall establish and maintain a Technical Risk Management process to include activities, requirements, guidelines, and documentation for management of the risk identified during the technical effort.	Yes	Risk Management Requirements and Guidelines in G-8000.4-001

NPR Reqt		Comply?	Justification
SE-20	Center Directors or designees shall establish and maintain a Configuration Management process to include activities, requirements, guidelines, and documentation for configuration management.	Yes	Configuration Management Requirements and Guidelines in DPD-8040.1-001
SE-21	Center Directors or designees shall establish and maintain a Technical Data Management process to include activities, requirements, guidelines, and documentation for management of the technical data generated and used in the technical effort.	Yes	Technical Data Management Guidelines in G-7120.5-001 Section 4.1.2
SE-22	Center Directors or designees shall establish and maintain a Technical Assessment process to include activities, requirements, guidelines, and documentation for making assessments of the progress of planned technical effort and progress toward requirements satisfaction.	Yes	Technical Assessment Guidelines in G-7120.5-001 Appendix C and Appendix D
SE-23	Center Directors or designees shall establish and maintain a Decision Analysis process to include activities, requirements, guidelines, and documentation for making technical decisions.	Yes	Decision Analysis Guidelines in G-7120.5-001 Appendix C

Appendix D: Reference Documents

b. DCP-P-025, Project Managers' Manual

d. DOP-R-604, Flight Load Laboratory Thermal-Structural Ground Test Hazard Analysis

e. DCP-S-007, Software Assurance

f. DCP-X-008, Tech Brief (T/B) & Mini Tech Brief (Mini T/B)

g. DCP-X-009, Airworthiness and Flight Safety Review Process

h. DCP-X-020, Flight Operational Readiness Review (ORR)

k. G-7900.3-001, Airworthiness and Flight Safety Review, Independent Review, Mission Success Review, Technical Brief and Mini-Tech Brief

l. G-7900.4-002, Operations Engineer's Handbook

Document History Log

Review Date: March 7, 2016

This page is for informational purposes and does not have to be retained with the document.

Baseline, 11-09-07

Baseline-1, 05-04-09

- Redline version created to satisfy NCR deadline. To be updated by Aug 3, 2009.

Baseline-2, 07-23-09

Note: This document was originally approved as DPR-1420.1. The signature page in this minor revision still shows the original number. The content of the document has not changed. The minor revision applies only to the addition of the document serial number.

- Changed document number from DPR-7123.1 to DPR-7123.1-001
- Pgs. 3 & 12, removed references to cancelled document DOP-M-106, Western Aeronautical Test Range (WATR) Mission Control Center (MCC) Systems Software Acceptance Testing

Revision A

- Relined to answer NCR

Revision B, 08-06-10

- Extended expiration date by 6 months

Revision C, 03-09-11

- Formatted to comply with Agency requirements
- Removed references to cancelled documents DCP-P-005, DCP-P-006, DHB-P-002, DOP-P-003
- Changed DHB-O-001 to G-7900.4-002
- Changed DHB-X-001 to G-7900.3-001
- Incorporated Section 5.0, description of the SE engineer processes and mapping to the DPR processes
- Addresses the audit finding, NPR 7123.1A requirements not flowed to center documentation
- Updated the Dryden lifecycle to include the SMB and PMB project development review process
- Added Appendix B Acronyms
- Added Appendix C Mapping of NPR 7123.1 Common Technical Processes
- Updated Figure 2, Designated Governing Authority at Dryden, which eliminates the associate director of operations.

Admin Change, C-1, 03-09-11

- Changed reference to DCP-$-604 to DOP-R-604

Revision D,

- Deleted part of 1.2 DPR Scope
- Deleted 1.4.1
- Deleted 1.5 Risk Management
- Deleted Chapter 2 Engineering Life Cycle Requirements
- Deleted Chapter 3 LifeCycle Review Criteria
- Deleted Chapter 4 Common Technical Process
- Updated Appendix C Mapping of NPR 7123.1 Common Technical Processes
- Added Appendix D Reference Documents
- Updated references to G-7120.5-001, Project Chief Engineer’s Handbook